

What is Claimed Is:

1 1. An apparatus for detection and measurement of trace species in
2 at least one of a sample gas and a sample liquid comprising:

3 a passive fiber optic ring having a portion thereof exposed to the
4 sample gas or sample liquid;

5 a coherent source of radiation;

6 coupling means for i) introducing a portion of the radiation emitted by
7 the coherent source to the passive fiber optic ring and ii) receiving a portion of the
8 radiation resonant in the passive fiber optic ring;

9 a detector for detecting a level of the radiation received by the
10 coupling means and generating a signal responsive thereto; and

11 a processor coupled to the detector for determining a level of the trace
12 species in the gas sample or liquid sample based on the signal generated by the
13 detector.

1 2. The apparatus according to claim 1, wherein the level of the
2 trace species is determined based on a rate of decay of the signal generated by the
3 detector.

1 3. The apparatus according to claim 1, wherein the coupling
2 means is a single optical coupler.

1 4. The apparatus according to claim 3, further comprising a filter
2 placed in an optical path between the coupling means and the detector to selectively
3 pass the received portion of radiation from the passive fiber optic loop to the
4 detector.

1 5. The apparatus according to claim 4, wherein the filter passes
2 radiation to the detector based on a wavelength of the radiation.

1 6. The apparatus according to claim 1, wherein the coupling
2 means includes i) a first coupler for introducing the portion of the radiation emitted

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3 by the coherent source to a first section of the fiber optic ring and ii) a second
4 coupler for receiving the portion of the radiation in the passive fiber optic ring at a
5 second section thereof.

1 7. The apparatus according to claim 1, wherein the exposed
2 portion is a cladding of the fiber.

1 8. The apparatus according to claim 1, wherein the exposed
2 portion is an inner core of the fiber.

1 9. The apparatus according to claim 1, wherein coherent source of
2 radiation is an optical parametric generator.

1 10. The apparatus according to claim 1, wherein coherent source of
2 radiation is an optical parametric amplifier.

1 11. The apparatus according to claim 1, wherein coherent source of
2 radiation is a laser.

1 12. The apparatus according to claim 1, wherein the coherent
2 source of radiation is a pulsed laser.

1 13. The apparatus according to claim 1, wherein the coherent
2 source of radiation is a continuous wave laser.

1 14. The apparatus according to claims 11, 12 or 13, wherein the
2 laser is an optical fiber laser.

1 15. The apparatus according to claim 13, wherein the continuous
2 wave laser is a tunable diode laser having a narrow band.

1 16. The apparatus according to claim 15, further comprising an
2 isolator coupled between the laser and the coupling means and in line with the
3 radiation emitted from the laser, the isolator minimizing noise in the laser.

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1 17. The apparatus according to claim 1, wherein an evanescent
2 field of the radiation traveling within the fiber is exposed to the sample gas or
3 sample liquid.

1 18. The apparatus according to claim 17, wherein the absorption of
2 the radiation from the fiber increases a rate of decay of the radiation received by the
3 coupling means.

1 19. The apparatus according to claim 1, wherein the passive
2 resonant fiber is formed from one of fused silica, sapphire and fluoride based glass.

1 20. The apparatus according to claim 1, wherein the passive
2 resonant fiber is formed from a hollow fiber.

1 21. The apparatus according to claims 19 or 20, wherein the
2 passive resonant fiber is a single mode fiber.

1 22. The apparatus according to claims 19 or 20, wherein the
2 passive resonant fiber is a multi-mode fiber.

1 23. The apparatus according to claim 1, further comprising at least
2 one cylindrical body having a predetermined diameter and wrapped with the
3 exposed portion of the optical fiber, wherein exposure of the evanescent field to the
4 trace species is enhanced by increasing a penetration depth of the evanescent field.

1 24. The apparatus according to claim 1, further comprising a
2 plurality of cylindrical bodies having respective predetermined diameters and
3 wrapped with respective sections of the exposed portion of the resonant fiber.

1 25. The apparatus according to claims 23 or 24, wherein the
2 tubular structure is a mandrel.

1 26. The apparatus according to claim 25, wherein the mandrel has a
2 cross sectional radius of at least about 1 cm.

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1 27. The apparatus according to claim 25, wherein the mandrel has a
2 cross sectional radius of between about 1 cm and 10 cm.

1 28. The apparatus according to claim 1, wherein the trace species is
2 at least one of water, acetylene and ammonia.

1 29. The apparatus according to claim 28, wherein the coherent
2 source is a single mode laser tunable in the wavelength region of about 1390 nm
3 and about 1513 nm.

1 30. The apparatus according to claim 1, wherein the passive fiber
2 optic ring resonates at a wavelength between a visible to a mid-infrared region of an
3 electro-magnetic spectrum.

1 31. The apparatus according to claim 1, wherein at least a portion
2 of the passive fiber optic ring is disposed within the liquid sample for determining a
3 presence of the trace species in the liquid sample.

1 32. The apparatus according to claim 1, wherein at least a portion
2 of the passive fiber optic ring is coated with a material to selectively increase a
3 concentration of the trace species at the coated portion of the fiber optic ring.

1 33. The apparatus according to claim 32, wherein the material
2 attracts analyte molecules of the trace species.

1 34. The apparatus according to claim 33, wherein the material is
2 polyethylene.

1 35. The apparatus according to claim 32, wherein at least the
2 coated portion of the passive fiber optic ring is disposed within the liquid sample for
3 determining a presence of the trace species in the liquid sample.

1 36. The apparatus according to claim 1, further comprising an input
2 detector for determining when energy from the laser is provided to the fiber optic
3 ring.

1 37. The apparatus according to claim 36, further comprising
2 control means to deactivate the laser based on the receiving means receiving
3 radiation from the fiber optic ring after the input detector determines that the laser
4 provided energy to the fiber optic ring.

1 38. The apparatus according to claim 37, wherein the control
2 means and the input detector are coupled to the processing means.

1 39. The apparatus according to claim 1, wherein an index of
2 refraction of the fiber is greater than an index of refraction of the sample liquid.

1 40. The apparatus according to claim 1, wherein an index of
2 refraction of the fiber is based on an index of refraction of the sample gas and an
3 absorption band of the trace species.

1 41. The apparatus according to claim 1, wherein the portion of the
2 radiation coupled into the fiber optic ring is less than about 1 % of the radiation
3 provided to the coupling means.

1 42. The apparatus according to claim 1, wherein the portion of the
2 radiation coupled into the fiber optic ring is variable.

1 43. The apparatus according to claim 1, wherein the portion of the
2 radiation coupled into the fiber optic ring is varied based on a loss within the
3 passive fiber optic loop.

1 44. The apparatus according to claim 43, wherein the loss within
2 the passive fiber optic loop is based on at least connector losses and fiber losses.

1 45. The apparatus according to claim 1, wherein the fiber optic ring
2 is at least about 1 meter long.

1 46. The apparatus according to claim 1, wherein the fiber optic ring
2 is at least about 10 meters long.

1 47. The apparatus according to claim 1, wherein the fiber optic ring
2 is at least about 1 Km long.

1 48. An apparatus for detection and measurement of trace species in
2 at least one of a sample gas and a sample liquid comprising:

3 a passive resonant fiber optic ring having a portion exposed to the
4 sample gas or sample liquid;

5 a coherent source emitting radiation;

6 a first optical coupler to provide at least a portion of the radiation
7 emitted by the coherent source to a first section of the passive resonant fiber ring;

8 at least one cylindrical body coupled to a portion of the exposed fiber
9 optic ring to form the portion of the exposed fiber optic ring with a predetermined
10 radius, at least a portion of the sample liquid or sample gas contacting the formed
11 portion of the fiber optic ring;

12 a second optical coupler for receiving a portion of the radiation in the
13 passive resonant fiber ring from a second section of the resonant fiber ring; and

14 a processor coupled to the second optical coupler for determining a
15 level of the trace species in the gas or liquid sample based on a rate of decay of the
16 radiation received by the second optical coupler.

1 49. The apparatus according to claim 48, further comprising a first
2 optical detector coupled between the second optical coupler and the processor for
3 generating a signal responsive to the radiation received by the second optical
4 coupler.

1 50. The apparatus according to claim 48, further comprising a
2 second optical detector coupled between the first optical coupler and the processor
3 for determining when energy from the laser is provided to the passive fiber optic
4 ring.

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1 51. The apparatus according to claim 50, wherein the second
2 optical detector generates a trigger signal to the processor responsive to receiving
3 radiation from the coherent source.

1 52. The apparatus according to claim 48, wherein the first and
2 second optical couplers are a unitary coupler.

1 53. A method for detecting and measuring a trace species in at least
2 one of a sample gas and a sample liquid, the method comprising:

3 exposing a portion of an optic fiber of a passive fiber optic ring to the
4 sample gas or sample liquid;

5 emitting radiation from a coherent source;

6 coupling at least a portion of the radiation emitted from the coherent
7 source into the fiber optic ring;

8 receiving a portion of the radiation travelling in the fiber optic ring;

9 and

10 determining the level of trace species in the gas or liquid sample based
11 on a rate of decay of the radiation within the fiber optic ring.

1 54. A method according to claim 53, further comprising the steps
2 of:

3 forming, with a predetermined radius, at least a portion of the exposed
4 portion of the passive fiber optic ring based on an absorption frequency of the trace
5 species; and

6 exposing the formed portion of the fiber to the sample liquid or
7 sample gas.

1 55. A method according to claim 54, further comprising the step of
2 exposing an evanescent field of the radiation traveling within the fiber to the sample
3 gas or sample liquid.

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- 1 56. A method according to claim 55, further comprising the step of
- 2 determining the level of the trace species in the sample gas or sample liquid based
- 3 on the rate of decay of the radiation in the fiber responsive to an absorption of the
- 4 radiation by the trace species.

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